THE WEATHER AND CIRCULATION OF AUGUST 1964

An Unusually Cool Month

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1. WEATHER HIGHLIGHTS

Strong cooling was one of the outstanding features of August's weather, although some of the more southerly parts of the United States remained warmer than normal; this was in contrast to July when, "warm and generally dry conditions prevailed in most of the Nation" [1]. In some sections of the country the lingering dry conditions were alleviated, but in other areas the shortage of rainfall became more critical.

Large sections of the Southern Plains reported rain which brought welcome relief from extended dryness. Heavy rain in the last two weeks of August in most of Minnesota and parts of Wisconsin also brought relief to the Upper Mississippi Valley, where the Mississippi River had reached an all-time low rate of ice-free flow at McGregor, Iowa.

The summer-long drought in portions of the Middle Atlantic States continued. Washington, D.C., Baltimore, Md., and Wilmington, Del., all with less than half normal rainfall, reported the driest summer of record in more than 60 yr. After having almost twice normal rainfall in July, Trenton, N.J., and nearby areas returned to the drought conditions of early summer with only one-tenth normal rainfall in August. New York, N.Y., with 0.24 in., reported the driest August since 1869; Philadelphia, Pa., with 0.49 in., had the second driest August since 1896. Many other sections of the Northeast reported fair amounts of rainfall in August but continued in great need of more rain because of the long-period deficiency.

Another major feature of August weather was hurricane Cleo which swept northward through Florida, Georgia, and the Carolinas; first estimates of damage were placed near $200 million. Details of this storm are discussed in section 6.

2. MEAN CIRCULATION

A sudden change occurred in the circulation of the Northern Hemisphere early in August. Andrews [1] noted during his discussion of the weather and circulation for July of this year that "The most unusual feature of the 700-mb. circulation for July was the extremely deep polar Low." He further stated that negative height anomalies had dominated the polar region ". . . during every month of 1964. . . ." In contrast, a feature of the 700-mb. circulation for August (fig. 1) was a ridge over the polar basin with a High center near where the polar Low is normally located. Heights of the 700-mb. surface over the Arctic in August were significantly above normal (fig. 2). A maximum positive value of 250 ft. was centered in almost the same position as the large 500-ft. negative anomaly of the previous month; the dramatic change pattern shown in figure 3 resulted. Strong anticyclonic activity was also present at sea level in the high latitudes (fig. 4). The positive sea level pressure anomaly covered about the same area as the upper-level positive departures, with a maximum value of 10 mb. centered over Greenland.

Outside the polar region changes of the mean circulation from July were less pronounced. While the high latitude flow exhibited a strong blocking pattern in August, the mid-latitude winds were quite zonal, particularly in the western portion of the Northern Hemisphere. A band of negative 700-mb. height anomaly (fig. 2) almost encircled the globe to the south of the large positive anomaly over the Arctic. This band of negative anomaly was associated with a slightly southward displacement of the westerlies (fig. 5A), and, since the subtropical Highs were stronger than normal, the speed of the westerlies was faster than normal over the United States and adjacent oceans (fig. 5B). Major long-wave troughs were located very close to the west and east coasts of the United States (fig. 1) near their usual positions; however the east coast trough had a negative tilt into an abnormally depressed Low along the eastern shore of Hudson Bay. Two other mean cyclonic vortices were in positions displaced from their usual higher latitude locations in August—one between Iceland and Scandinavia, and the other over northeastern Siberia. The only major mean Low that was near its normal location was the one along the north central coast of Siberia.

3. TEMPERATURE

The warm air that was associated with the strong ridge

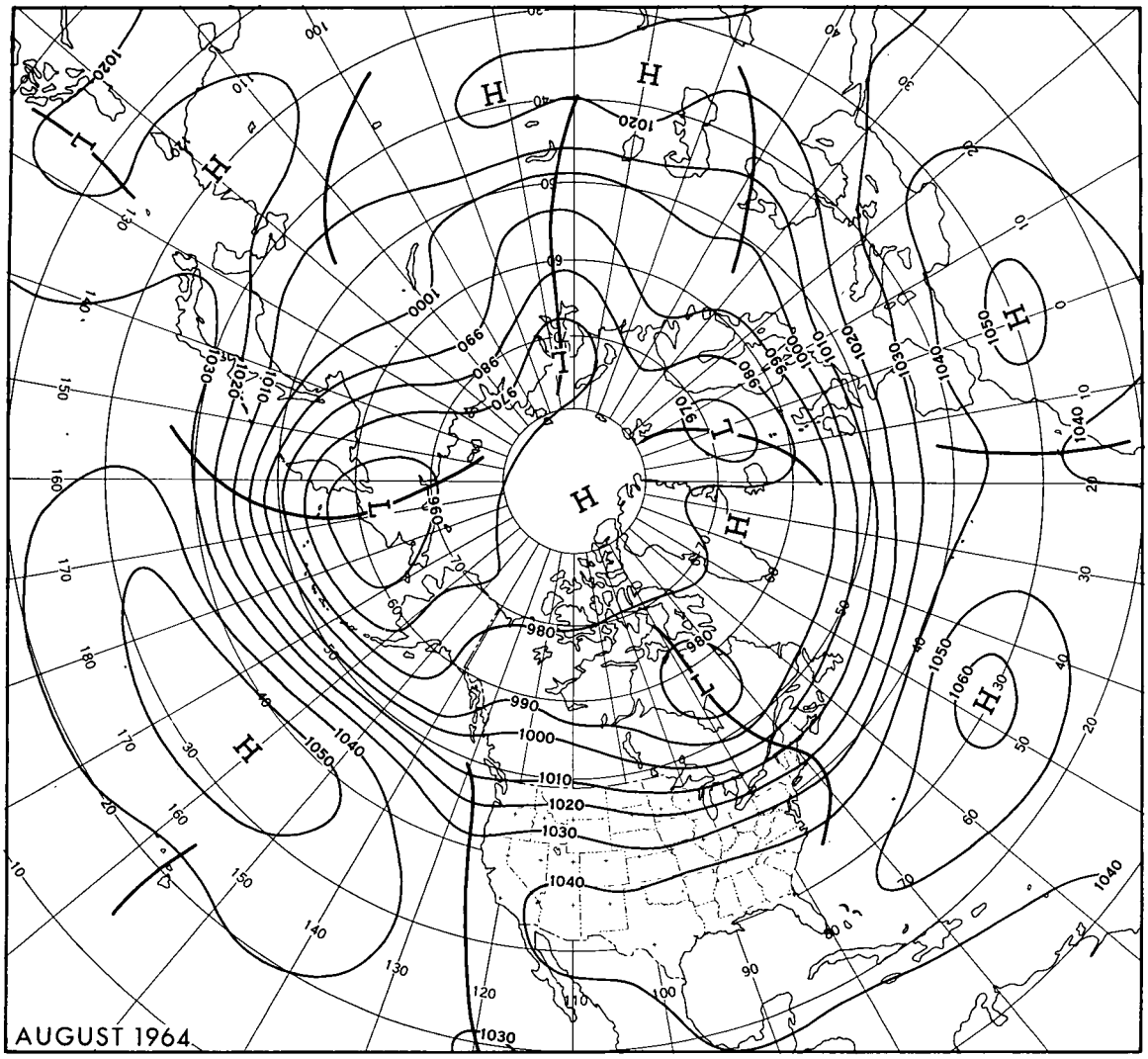

FIGURE 1.—Mean 700-mb. contours (tens of ft.) drawn at intervals of 100 ft. for August 1964. Anticyclonic flow was observed over the polar basin for the first month this year.

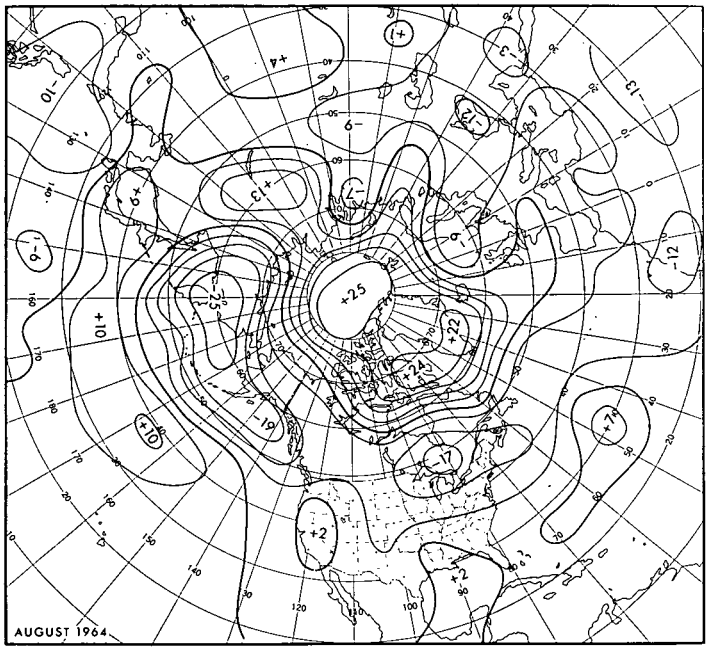

FIGURE 2.—Mean 700-mb. height departures from normal for August 1964 at intervals of 50 ft., with centers labeled in tens of feet and the zero isopleth heavy. A blocking pattern was present at high latitudes.

over central North America in July [1] was replaced during August by very cool air accompanying the large shift in the hemispheric circulation. In the upper Mississippi Valley and Northern Plains, where some of the relatively warmest air was observed in July, large negative temperature anomalies were recorded in August (fig. 6). After initially hot weather over much of the Nation, the coolness became very persistent, relenting only in the Northeast in the final week of August. Somewhat warmer than usual weather did continue all of the month, however, in southern Texas, Arizona, and Florida.

The intensity and persistency of the cool air gave many sections the coolest August in the past 50 years. Table 1 lists several of the cooler stations. Portland, Maine, with 92 years of temperature observations, reported the coolest August of record. The anomaly patterns of surface temperature (fig. 6) and of 700-mb. height (fig. 2) corresponded closely. The relatively warmest area, located in western Texas, was associated

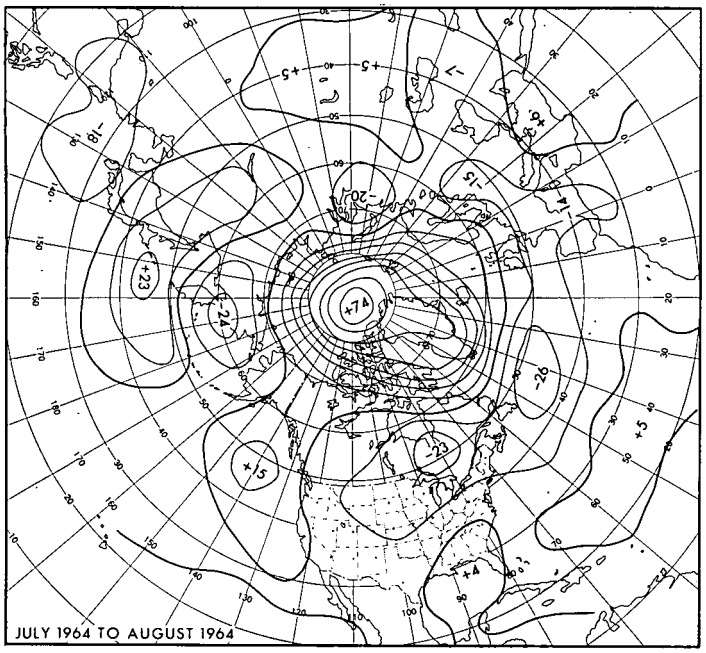

FIGURE 3.—Mean 700-mb. height change (tens of ft.) for July to August 1964. Extremely large height rises over the polar region were associated with the cool weather in the United States.

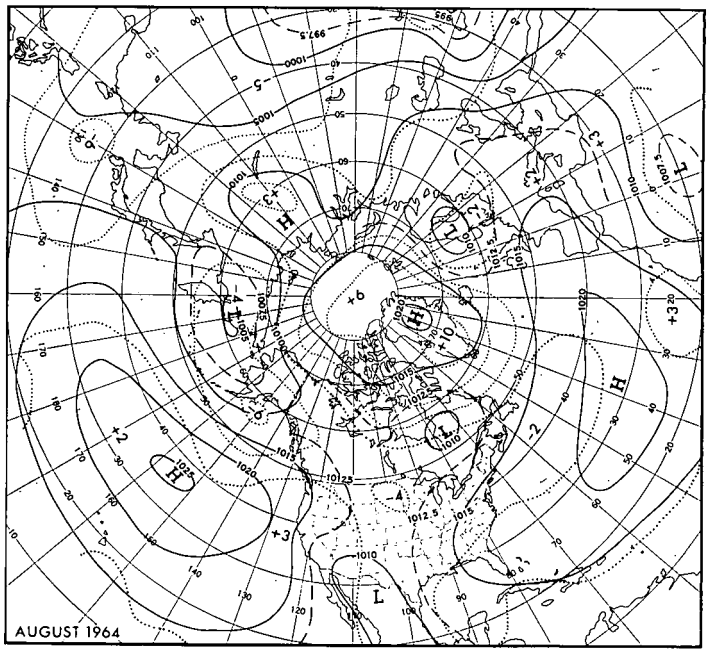

FIGURE 4.—Mean sea level isobars (solid) and departures from normal (dotted), both in millibars, for August 1964. Outstanding feature is the large positive anomaly over the Arctic.

with southerly anomalous flow and height values that were near normal; an objective method for specifying the surface temperature from the mean 700-mb. height pattern [2] indicated the largest positive temperature anomalies should be expected in this section.

4. PRECIPITATION

With the collapse of the strong ridge over North America during July, the resulting more frequent and more intense cyclonic activity during August brought precipitation to areas that were fairly dry in July. However, the distribution of rainfall was extremely varied (fig. 7), and nearby contrasts were frequent. Just south of drought-stricken Washington at Richmond, Va., 9.88 in. fell; 4.18 in. was reported at Williamsport, Pa., a little more than 100 mi. from Philadelphia which had only 0.49 in.; and more than 6 in. of rain occurred in coastal Texas not far from Corpus Christi, which had only 0.50 in. Billings, Mont., reported the wettest August in 30 years; yet Cheyenne, Wyo. had only 18 percent of normal rainfall. Cheyenne had received less than half normal precipitation since the beginning of 1964, the driest first 8 months in the century. The precipitation contrast was also present in Oregon; some sections in the eastern part of the State recorded up to four times the normal rainfall, while Pendleton again reported below normal rain and had received only 8.49 in. in the last 12 months—the driest September to August period since 1890.

The dryness in some parts of the West resulted in frequent range fires. In Nevada, Elko reported 30 fires in one day and 350,000 acres of range burned in northeastern Nevada this season, and Reno reported several large and numerous small range fires.

Hurricane Cleo was responsible for most of the continued heavy rains in southeastern United States. The monthly totals were much less than those of July in the Southeast but were still above normal in many sections.

5. WEEKLY EVOLUTION

Although the salient feature of August weather was coolness dominating most of the United States, the planetary waves of the middle latitudes were not stagnant. Slow retrogression was apparent from week to week. A temperature cycle was noticeable also, as conditions changed from warm over much of the western two-thirds of the Nation and cool in the East the first week to very cool for this season over most of the country the second week. Then small areas of the East began to have near

TABLE 1.—*Extreme low mean temperature for August recorded in 1964*

Station	Monthly average temperature (° F.)	Departure from normal (° F.)	Number of years since greater extremes observed
Rockford, Ill.	66.9	−5.6	49
Portland, Maine	66.1	−5.7	92
Boston, Mass.	66.4	−5.3	61
Worcester, Mass.	63.4	−4.9	63
Missoula, Mont.	60.8	−4.0	68
Concord, N.H.	62.7	−4.7	61
Bismarck, N. Dak.	64.8	−4.5	40
Providence, R.I.	66.6	−3.9	59
Walla Walla, Wash.	69.7	−4.1	52
Yakima, Wash.	62.8	−5.8	53

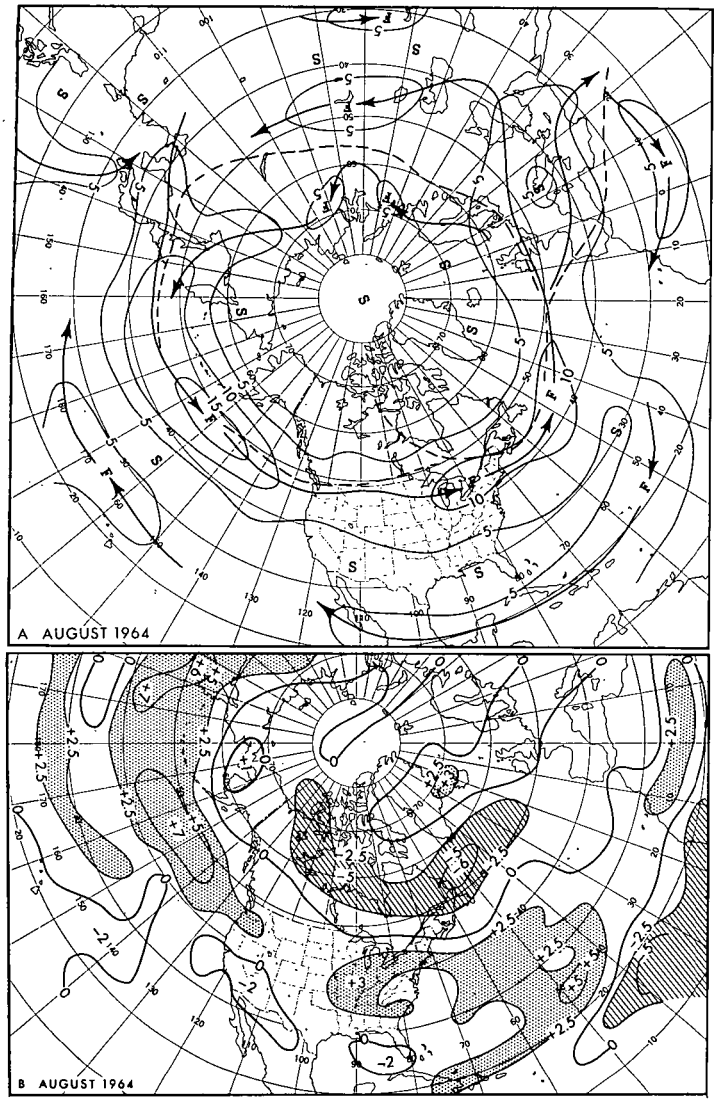

FIGURE 5.—(A) Mean isotachs at 700-mb. and (B) deparature from monthly normal wind speed (both in m./sec.) for August 1964. Solid arrows in (A) indicate the primary axes of the maximum wind, dashed line the normal.

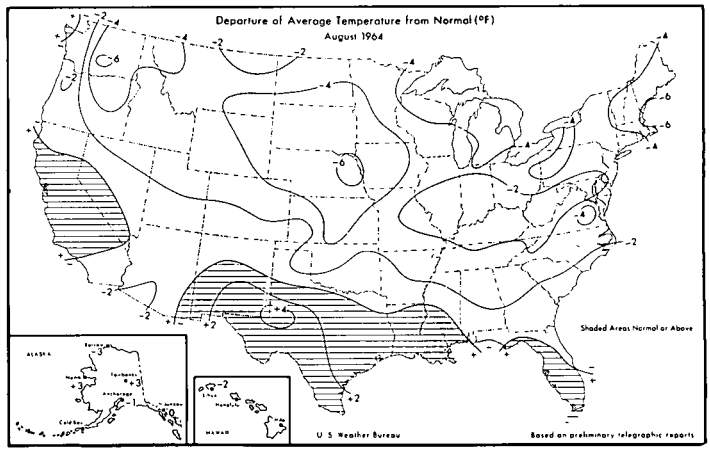

FIGURE 6.—Departure of average surface temperature from normal (°F.) for August 1964 (from [3]). An unusually cool August followed a warm July in most sections.

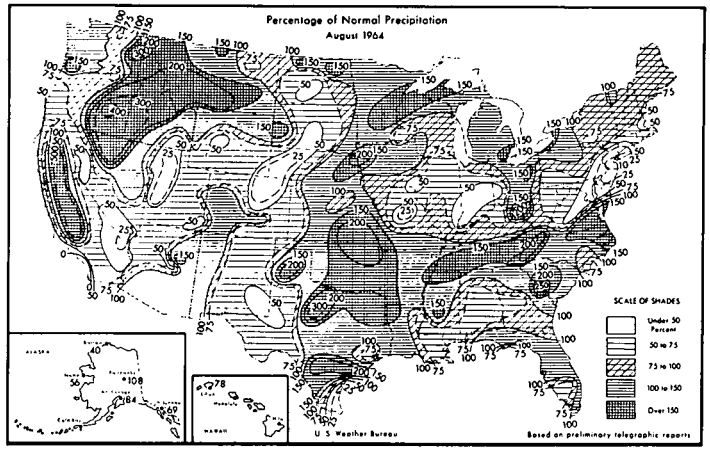

FIGURE 7.—Percentage of normal precipitation for August 1964 (from [3]). A highly variable precipitation pattern was observed.

normal temperatures the third week, and during the final week strong warming in the Northeast contrasted with the coolest weather of the month in the west coast States.

During the first week of August the deep polar Low that had persisted for several months [1] began to weaken and shift southward; at the same time, the ridge over North America moved westward and strengthened (fig. 8A). These events, resulting in two surges of cool air from Canada into eastern United States during the week, gave the temperature pattern shown in figure 8B. The precipitation for the first several days of August continued generally light (fig. 8C), but heavy rain fell in frontal showers and thunderstorms over scattered areas eastward from the Rocky Mountains. The very heavy rain in coastal Texas was caused by tropical storm Abby that moved inland and dissipated rapidly.

In the second week of August the deep upper-level Low that had been over the polar basin moved southward into eastern Canada as rapid anticyclogenesis occurred over the Arctic (fig. 9A). 700-mb. heights were 800 ft. above normal where only a short while before a very large negative height anomaly had prevailed. An unusually cold mass of air, perhaps the coldest air mass to enter the United States during the second week of August in the past 100 years, spread southward from the Arctic during this week and covered most of the United States east of the Rocky Mountains. Negative temperature anomalies for the week were as much as 15° (fig. 9B). The surface weather map at 1200 GMT August 12 showed about 2500 mi. of almost direct northerly wind from northern Texas to north of Hudson Bay. There were 36 stations from North Dakota to New England that observed record minimum temperatures during the week. Table 2 lists some of these stations, and shows the length of the record of many to be more than 90 years. Again, as in the previous week, precipitation in the vicinity of fronts produced the heavier rain (fig. 9C).

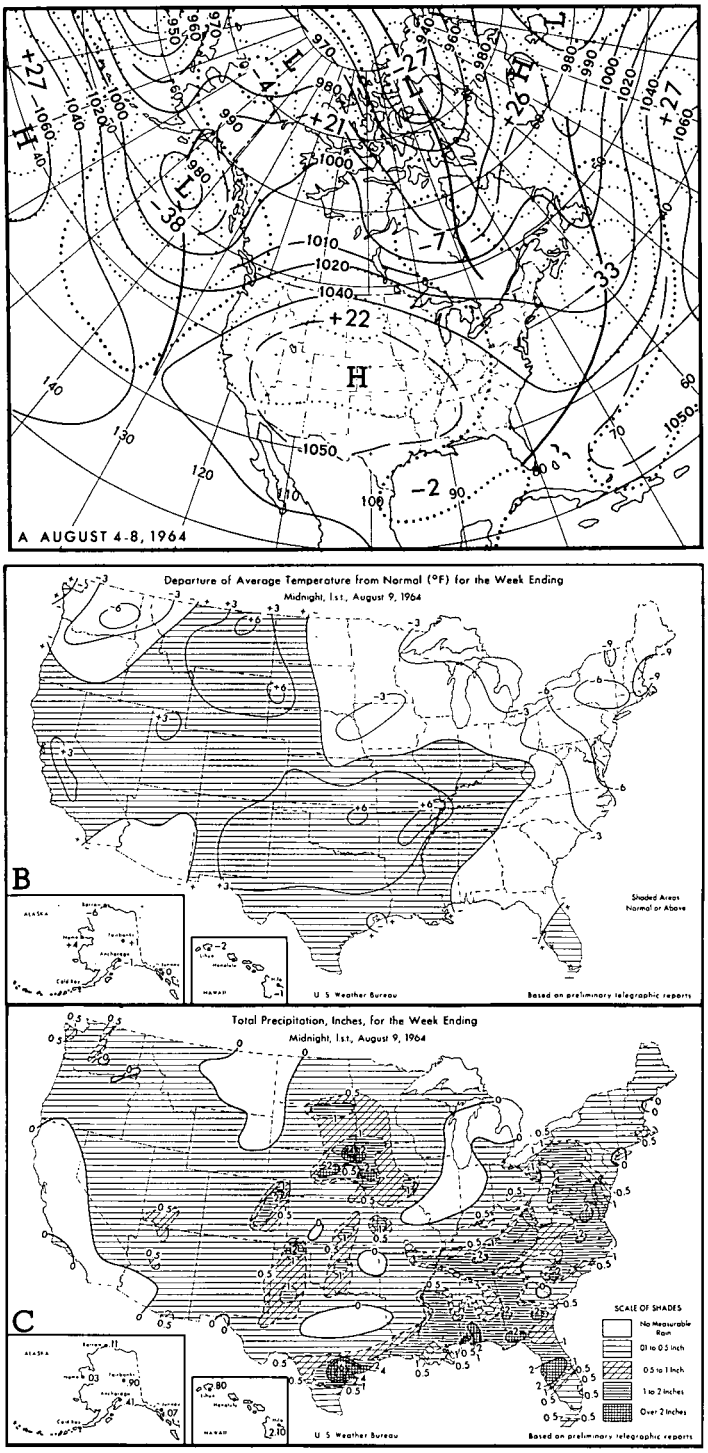

FIGURE 8.—(A) 700-mb. contours (solid) and height departures from normal (dotted), both in tens of feet, for August 4–8, 1964. (B) Surface temperature departure from normal (°F.) and (C) total precipitation (in.) for the week ending August 9, 1964 (from [3]).

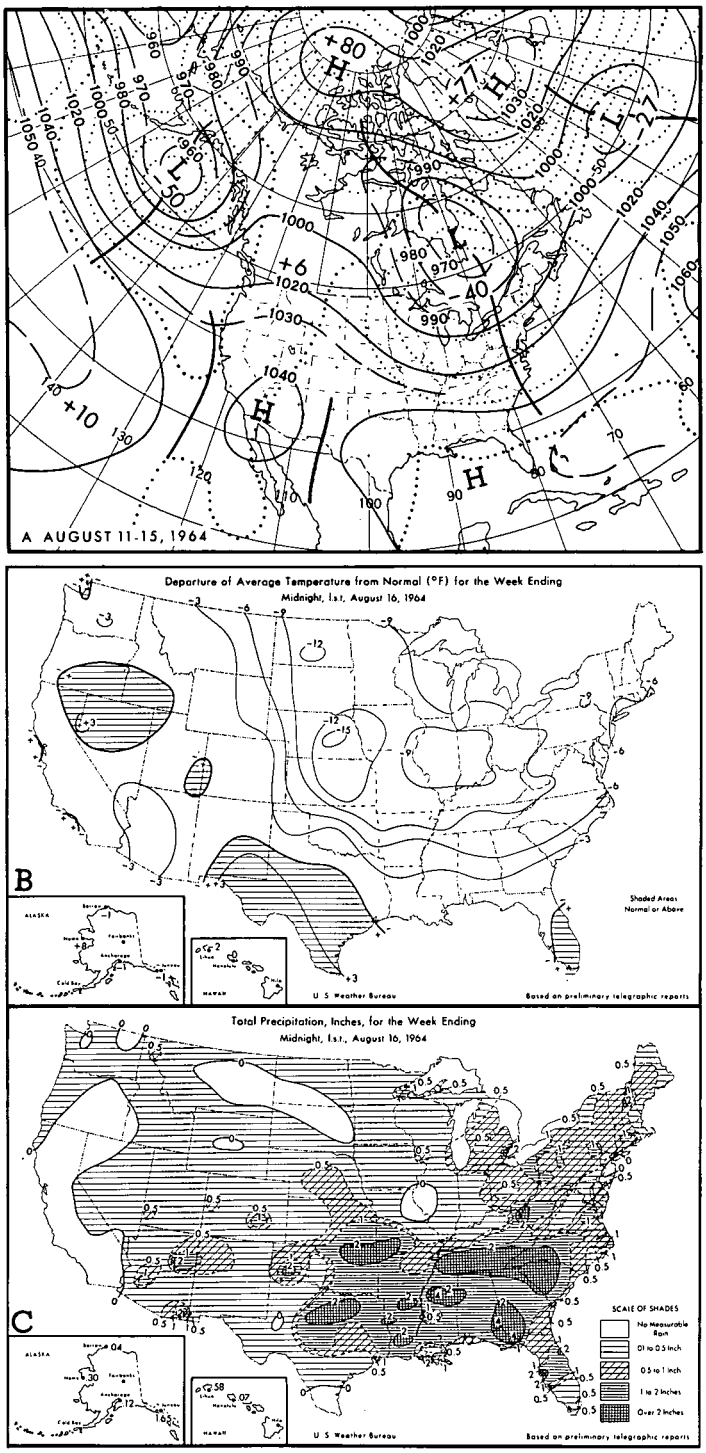

FIGURE 9.—(A) 700-mb. contours (solid) and height departures from normal (dotted), both in tens of feet, for August 11–15, 1964. (B) Surface temperature departure from normal (°F.) and (C) total precipitation (in.) for the week ending August 16, 1964 (from [3]).

Retrogression continued during the third week as the western ridge moved off the Pacific Coast and a mean trough became established in the Midwest (fig. 10A). At the same time a blocking High moved into Canada directly north of the trough over the Plains. As a consequence, another cool air mass that was guided southward by the northerly flow in eastern Canada affected many eastern States, while the strong Pacific ridge deployed cold air farther west (fig. 10B). Precipitation was heaviest this week just east of the mean trough in

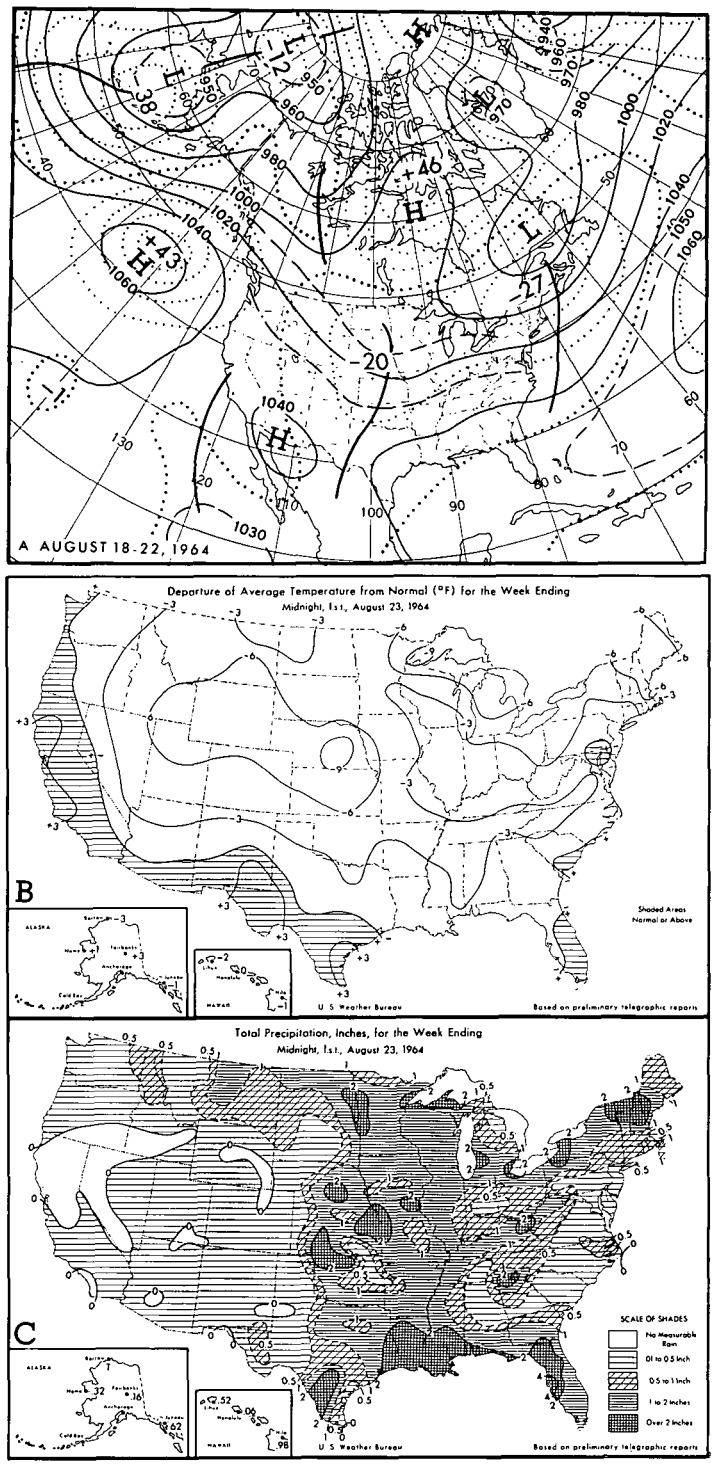

FIGURE 10.—(A) 700-mb. contours (solid) and height departures from normal (dotted), both in tens of feet, for August 18–22, 1964. (B) Surface temperature departure from normal (°F.) and (C) total precipitation (in.) for the week ending August 23, 1964 (from [3]).

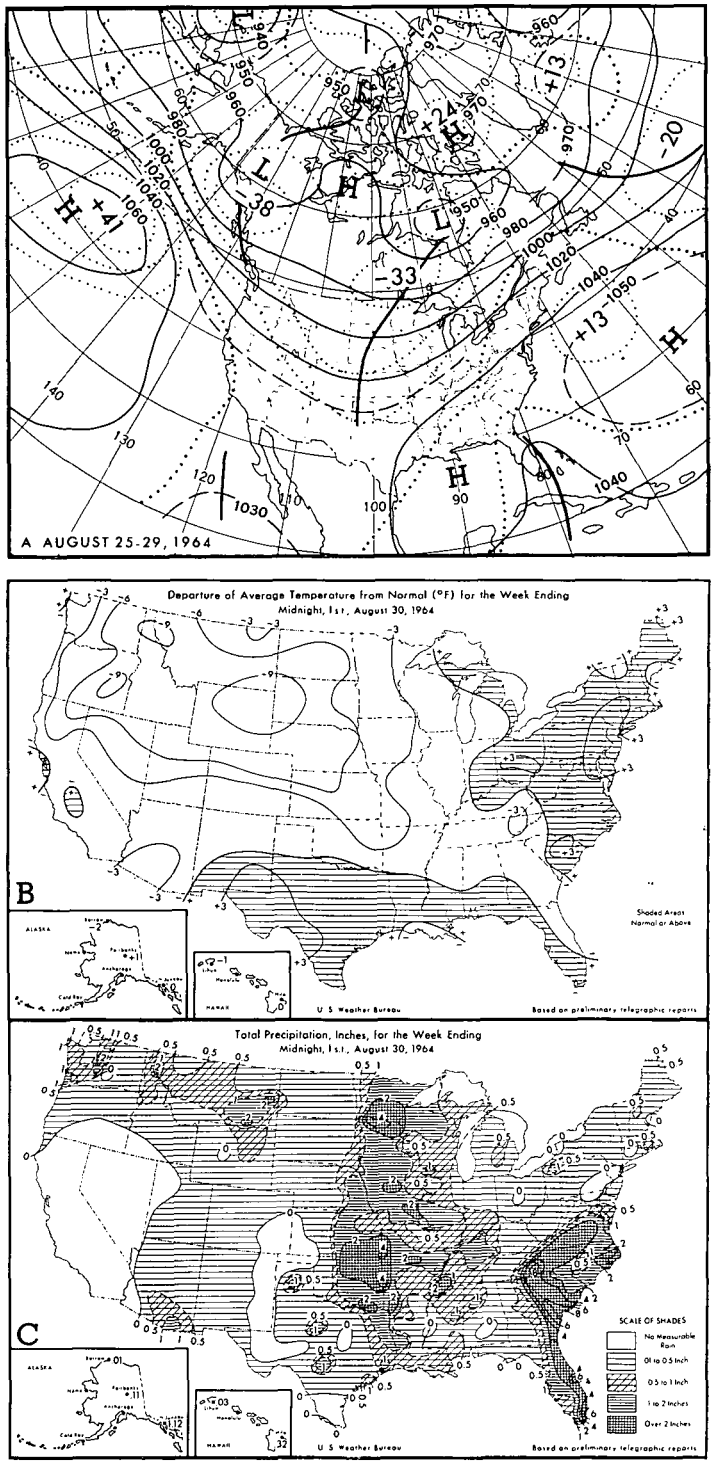

FIGURE 11.—(A) 700-mb. contours (solid) and height departures from normal (dotted), both in tens of feet, for August 25–29, 1964. (B) Surface temperature departure from normal (°F.) and (C) total precipitation (in.) for the week ending August 30, 1964 (from [3]).

the Plains (fig. 10C) and was more closely associated with surface cyclones, instead of being mainly frontal. Heavy rain did occur in parts of Montana and North Dakota, as cyclonic systems moved from the west into the mean trough.

The ridge that had moved off the west coast the week before retrogressed further in the final week of August, while the subtropical High in the Atlantic moved toward the Southeast (fig. 11A). Concurrently, the 700-mb. Low that had been over Labrador moved westward to

TABLE 2.—*Stations establishing daily record minimum temperatures in August 1964*

Selected stations	Minimum temperature (° F.)	Date	Length of record (yr.)
Waterloo, Iowa	41	14	68
Dodge City, Kans.	55	12	89
Louisville, Ky.	49	13	92
Boston, Mass.	52	15	92
Detroit, Mich.	48	14	93
Duluth, Minn.	36	14	90
Springfield, Mo.	48	12	76
North Platte, Nebr.	38	12	89
New York, N.Y.	54	14	95
Bismarck, N. Dak.	33	12	89
Cleveland, Ohio	46	14	93
Philadelphia, Pa.	53	16	93
Huron, S. Dak.	36	13	82
Nashville, Tenn.	54	13	93
Norfolk, Va.	55	15	93
Parkersburg, W. Va.	47	15	76
Madison, Wis.	37	14	107

Hudson Bay and combined with the trough over the Plains, as the ridge in Canada weakened and also shifted westward. Negative 700-mb. height departures over central United States became larger as the mean trough in the Plains and Upper Mississippi Valley was almost stationary for a few days. However, conditions were becoming suitable for the retrogression of this trough, as the relatively shallow but intense trough shown in figure 11A along the western coast of Canada was moving southward and deepening. A five-day mean chart centered on the last day of August (not shown) revealed retrogression of the main trough to near the west coast.

As would be expected with the push of the Atlantic ridge to near the east coast, above normal temperatures were observed in the Middle Atlantic States and the Northeast for the first time in August (fig. 11B). The area of warm air which had been in and near Texas during the three previous weeks expanded somewhat, and above normal temperature was again observed all along the coast of the Gulf of Mexico. The Far West averaged cooler than normal this week for the first time in August.

Migratory storms again brought heavy precipitation to much of Montana and parts of Wyoming and Idaho in the last week of August (fig. 11C). Snow was reported in the mountains of Montana and Wyoming in both of the last two weeks of the month. At the Medicine Wheel Ranger Station near Sheridan, Wyo., 19 in. of snow fell on the 21st, and snow was reported in the Montana mountains on the 19th. A more general snow August 29 deposited 12 in. of snow on U.S. Highway 14 in the Wyoming mountains. A trailing front from a storm moving eastward through Canada and two subsequent storms, which both moved from eastern Colorado across the Great Lakes, produced the heavy rainfall in parts of the Eastern Plains and the Mississippi Valley the last week of August. Hurricane Cleo caused the very heavy rains in the Southeast.

6. TROPICAL STORMS

Most tropical storm activity during August was in the western Pacific, where six disturbances reached tropical storm intensity. One of these storms, typhoon Helen, which was just south of Japan on August 1, moved through the Yellow Sea into China. The second typhoon of the month, Ida, developed east of the Philippines and moved westward across Luzon, then passed very closely south of Hong Kong and into southern China. Between August 11 and 15 four tropical storms formed in rapid succession east of the Philippines and south of Japan. Two of these dissipated shortly after forming. The remaining two developed typhoon intensity and slowly rotated around each other in the fashion typical of nearby cyclonic vortices until the older and larger storm, Kathy, engulfed the other. Kathy moved across southern Japan into the Sea of Japan, then eastward across Japan near the 40th parallel, finally becoming extratropical about August 27.

One tropical storm detected in the eastern Pacific near 15° N., 110° W. on the 19th drifted slowly northwestward and lost its identity after the 23d.

Three tropical storms were observed in the Atlantic and the Gulf of Mexico. Only one of these storms, Cleo, reached hurricane strength. The other two were short lived.

Hurricane Abby formed in the Gulf of Mexico near the Texas shore, moved inland, and caused the heavy rains in Texas mentioned before; no major wind damage was attributed to Abby. Brenda formed just west of Bermuda and moved across the island with sustained wind speeds of 39 kt. and gusts to 56 kt. A tornado with measured wind speeds of 80 kt. formed within Brenda and damaged several aircraft.

Cleo, the storm that was most important for the United States mainland, was detected August 20 about 1000 mi. east of the lesser Antilles. After reaching hurricane strength, this storm passed over Guadeloupe, F.W.I., during the afternoon of the 22d, then moved across the northern Caribbean, affecting the Virgin Islands, Puerto Rico, and Hispaniola. Cleo passed northeast of Jamaica on the 24th and over Cuba west of Santiago on the 25th. The center of the 10- to 16-mi.-diameter eye crossed the northeastern section of Miami on the morning of the 27th. With the center remaining inland 10 to 20 mi., the storm moved north about 300 mi. until it passed briefly over the ocean around Jacksonville on the 28th and had its final landfall in Georgia the same day. This hurricane then weakened, advanced northward through the Carolinas, and returned to the Atlantic Ocean between Norfolk and Cape Hatteras on the morning of September 1. The storm again attained hurricane intensity at sea, but as it passed east of Newfoundland on the 4th, it lost its tropical features.

Major wind damage from Cleo was confined to a narrow strip along the Florida coast from Miami to Melbourne. Conservative estimates placed damage in Florida slightly under $120,000,000. From Georgia northward, damage

was mostly attributable to local flooding. Several tornadoes imbedded in Cleo's circulation caused wind damages estimated at almost $400,000 in the Carolinas.

Rainfall amounts were heaviest just before the storm returned to sea near Norfolk. At the Black Bay Wildlife Refuge, 25 mi. southeast of the Norfolk airport, 14.09 in. of rain fell during the passage of the hurricane, and at Norfolk the storm total was 10.40 in. Not all these heavier amounts are reflected in figure 7 for two reasons: The bulletin from which figure 7 was obtained is based on preliminary telegraphic reports, and some of the total rainfall attributed to Cleo occurred after the end of August.

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